

Advanced Lung Cancer Invading the Left Atrium, Treated with Pneumonectomy Combined with Left Atrium Resection under Cardiopulmonary Bypass

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A 68-year-old man presented with a chief complaint being a cough. Based on a bronchoscopic biopsy, it was diagnosed at a nearby clinic as an advanced left lung cancer, and he was referred to our hospital. Chest computed tomography (CT) scans demonstrated a giant mass of the left lower lobe, 14 × 12 cm in size, which appeared to have invaded the left atrium (LA). The operation was started with double vena cava cannulation via the right internal jugular vein and the right femoral vein as well as arterial cannulation via the right femoral artery. The patient underwent left pneumonectomy combined with LA resection using cardiopulmonary bypass (CPB), without aortic clamping, through left posterolateral thoracotomy under hypothermia (32°C). The tumor-invaded LA was resected in a 3.5 × 3.0 cm area, with vascular clamping, and the stump was closed with 3-0 Prolene sutures. The surgical margin was free of tumor cells, and the duration of CPB was 28 minutes. The patient was smoothly weaned from CPB. His postoperative course was uneventful, and he received 2 courses of adjuvant chemotherapy. For a combined resection of the LA, it is safer to use CPB than simple vascular clamping, since the latter involves the risk of dislocation. If CPB is used, the tension of the LA is removed by blood extraction into the bypass, and bradycardia is induced by a reduction of body temperature, probably reducing the risk of clamp dislocation. Even when clamp dislocation or bleeding resulting from injury of the LA wall unfortunately takes place during surgery, these events can be dealt with appropriately during the use of CPB. (*Ann Thorac Cardiovasc Surg* 2010; 16: 286–290)

Key words: advanced lung cancer, left atrial invasion, combined resection of left atrium, cardiopulmonary bypass

Introduction

Among cases of T4 lung cancer, those with a tumor invading the left atrium (LA) or superior vena cava (SVC) have been considered at many facilities as being indicated for surgical treatment.¹⁾ This is probably for the following reasons: (1) LA and SVC are the organs neighbor-

ing the lung most likely to be invaded by lung cancer earlier than any other organ/tissue, depending on the location of the primary lesion; and (2) resection of LA or SVC in combination with resection of the primary lung tumor is relatively easy if the extent of combined resection needed is not wide. However, in cases where the tumor has invaded extensively, combined resection is not

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Fig. 1. Chest X-ray on admission reveals the shadow of a giant lung tumor (14 cm in diameter) in the left lower lung field.

easy. We recently encountered a case of advanced lung cancer invading the LA and treated it with left pneumonectomy combined with LA resection under cardiopulmonary bypass (CPB). This paper will present this case and discuss the advantages and disadvantages of the use of CPB for a combined resection of LA, with reference to the literature.

Case Report

The patient was a 68-year-old man. He had been a heavy smoker (40 cigarettes/day) for 50 years. In May 2008, he began to show coughing, but left it untreated. The health checkup in September of the same year revealed an abnormal shadow on a chest X-ray. A chest computed tomography (CT) in October disclosed a giant tumor in the left lower lobe. He thus received a bronchoscopy at a nearby clinic and was found to have a tumor of the left lower bronchus. It was rated by biopsy as group V (squamous cell carcinoma). The patient was referred to us and admitted to our department in December of the same year to receive surgery. He had shown an 8-kg weight loss over the past 3 months.

Biochemically, mild anemia (Hb: 10.2 g/dl) and elevation of inflammatory reaction (CRP: 10.46 mg/dl) were noted. All tumor markers other than carcinoembryonic antigen (CEA) were high (CEA: 3.8 ng/ml; SCC: 5.8 ng/ml; CYFRA: 54 ng/ml; NSE: 34 ng/ml). A respiratory function test revealed signs of restrictive respiratory disorder (VC:

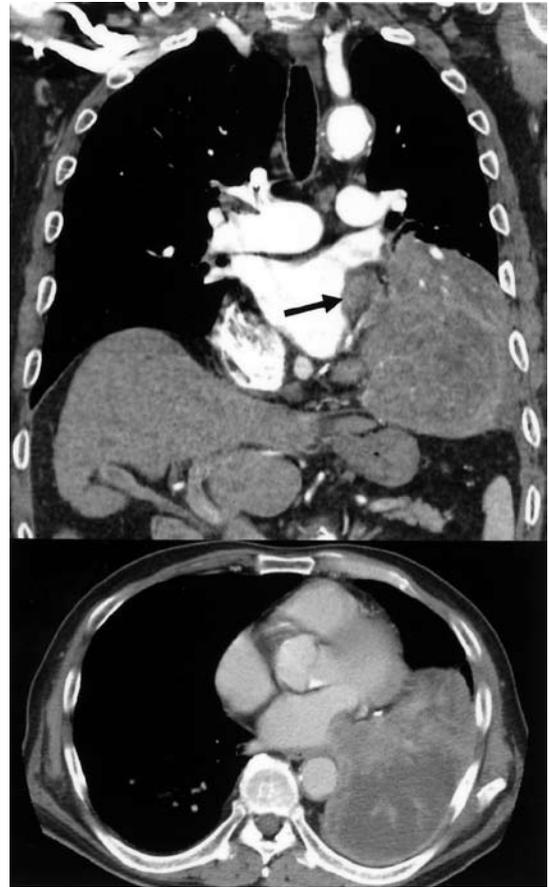


Fig. 2. Chest CT scans disclose a giant tumor almost completely occupying the left lower lobe. Blood flow through the left inferior pulmonary vein is not visualized, strongly suggesting tumor invasion of the left atrium.

2.04 L; %VC: 63.7%; FEV_{1.0}: 1.57 L; %FEV_{1.0}: 81.8%). In arterial blood gas analysis (room air), all parameters were approximately normal (pH: 7.475; PaCO₂: 36.9 mmHg; PaO₂: 80.4 mmHg; BE: 3.6 mmol/L).

A chest X-ray on admission (Fig. 1) revealed the shadow of a giant lung tumor (14 cm in diameter) in the left lower lung field. Chest CT scans (Fig. 2) disclosed a giant tumor occupying the left lower lobe almost completely. The area inside the tumor was poorly contrast-enhanced, suggesting necrotic degeneration. Blood flow through the left inferior pulmonary vein was not visualized, strongly suggesting tumor invasion of the LA. The lymph nodes around the left main bronchus were swollen, suggesting lymph node metastasis. Echocardiography revealed compression of the LA from outside, a result of the lung tumor, suggesting that the tumor had invaded the LA, reaching a point near the posterior cusp of the mitral valve. Head magnetic resonance imaging (MRI) and a

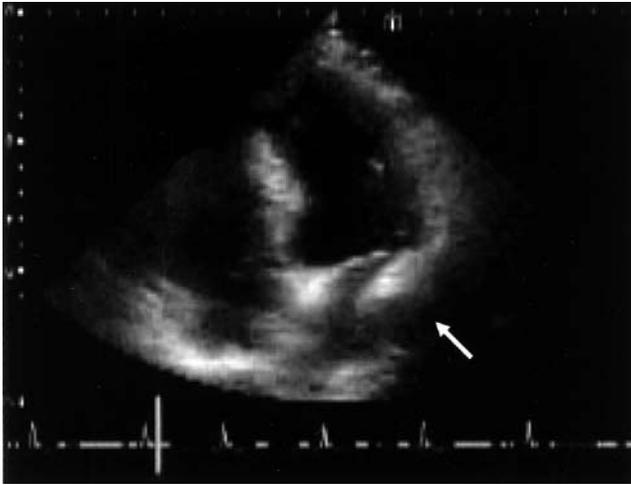


Fig. 3. Echocardiographic finding. Compression of the left atrium from outside because the lung cancer is visible, suggesting tumor invasion to a point near the posterior cusp of the mitral valve.

nuclear medicine test yielded no findings suggesting distant metastasis.

These results allowed judgment of a giant squamous cell carcinoma originating from the lower lobe of the left lung. Although LA invasion was strongly suggested, we judged that complete resection of the tumor would be possible by left pneumonectomy combined with resection of the invaded LA wall under CPB. Surgery was carried out in December 2008. Prior to open chest surgery in the right lateral decubitus position, cannulation for CPB was carried out, including double vena cava cannulation via the right internal jugular vein and the right femoral vein as well as arterial cannulation via the right femoral artery. Heparin treatment was started at that time. If tumor invasion of the LA is found to be intense after thoracotomy, it will be necessary to perform a resection of the invading tumor while checking the extent of invasion by means of a left atrial incision during cardiac arrest. In view of such a possibility, we started the operation by a left posterolateral incision at the fifth intercostal space, also taking into account the possible necessity of an additional incision upward along the median line where we can apply a cross clamp to the ascending aorta. The tumor had a diameter of 14 cm and completely occupied the left lower lobe. Invasion of the diaphragm and pericardium was also suspected. To allow combined resection of the possibly tumor-invaded diaphragm, thoracotomy at the 8th intercostal space was also made. This was followed by an approximately 10 × 10 cm resection of the diaphragm. The esophagus was judged to have only

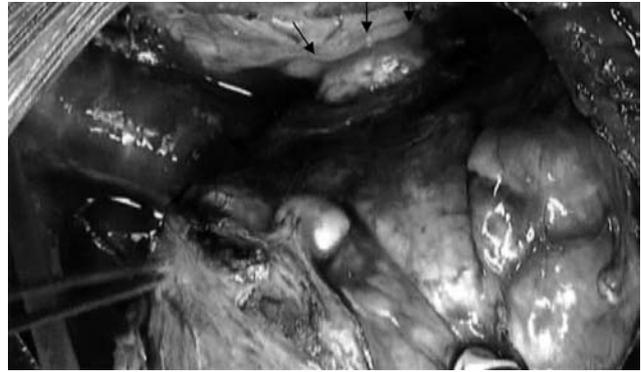
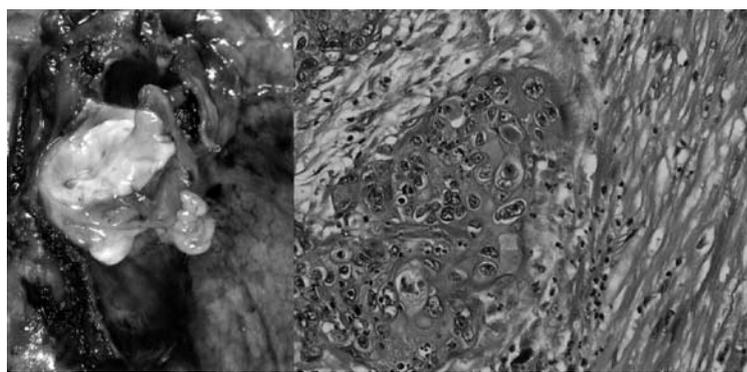


Fig. 4. Intraoperative finding I. Tumor invasion is marked at the junction of the left inferior pulmonary vein to the left atrium.

adhesion and to be free of tumor invasion. Outside the pericardium, the left main pulmonary artery and the left main bronchus were treated with an autosutured device. The pericardium was then vertically opened to a large extent, followed by treatment of the left superior pulmonary vein with an autosutured device. The tumor made it impossible to expose the left inferior pulmonary vein, and tumor invasion was evident where the left inferior pulmonary vein entered the LA (Fig. 4). At that time, we judged it possible to perform a combined resection of the LA, using a vascular clamp without opening the LA. However, since the area that could be covered with clamping was about 6 cm, we believed it necessary to use CPB to ensure safe resection of the LA. After blood began to be guided out into the bypass, the tension within the LA was removed, making it easier to apply the clamp. At that time, body temperature decreased to 32°C (a condition of bradycardia), making operative manipulations easier. In this way, without requiring complete arrest of the heart and with the heart kept beating, two side clamps were allied to the LA with an adequate surgical margin from the tumor-invaded area, and the LA was dissected to complete a left pneumonectomy combined with partial resection of the LA. Furthermore, an adequate margin was ensured when the anterior and posterior walls of the LA were both also incised by about 5 mm. The LA was then ligated and closed with 3-0 Prolene sutures (Fig. 5). The body temperature was then elevated to 35°C, and the patient was subsequently weaned from CPB and treated with protamine. The duration of CPB was 28 minutes. The pericardial defect was filled with an expanded polytetrafluoroethylene (ePTFE) patch. The concomitantly resected diaphragm was closed with direct suture. A thoracic drain was kept inserted, and the surgical wound



Fig. 5. Intraoperative finding 2. The left atrium was closed with 3-0 Prolene sutures after combined resection.



A | B

Fig. 6. Histopathological findings.

A: Macroscopic. Cancer affecting the entire lower lobe of left lung ($14 \times 12 \times 7$ cm in size) and the left atrial wall resected for a 3.5×3.0 cm area.

B: Microscopic invasion by a well-differentiated to moderately differentiated squamous cell carcinoma in the left atrial wall.

was closed by the routine method to complete the operation. Under the influence of the use of heparin, the volume of intraoperative blood loss (1,400 ml) was slightly more than average.

Postoperative mechanical ventilation was performed only on the day of surgery. One day after surgery, the patient could be weaned from the ventilator. His postoperative course was uneventful, and no noteworthy complication was noted. In the total of intraoperative and postoperative periods, the patient received transfusions of 11 packs of concentrated erythrocyte preparation. From the postoperative day 21, 2 courses of uncombined docetaxel (60 mg/m^2 , day 1) were administered as an adjuvant chemotherapy. The patient was discharged from the hospital on postoperative day 56. Since then, the patient has received oral TS-1 therapy (80 mg/day , each course consisting of a 4-week treatment and a subsequent 2-week cessation). At present, 17 months after surgery, the patient is alive without a significant health problem.

Histopathologically, the tumor had a diameter of $14 \times 12 \times 7$ cm, occupying the left lower lobe completely. This

tumor was resected, accompanied by 3.5×3.0 cm resection of the LA wall. It had invaded the left lower bronchus through the peripheral subpleural region, accompanied by a formation of necrotic voids. Histologically, the tumor was rated as a well-differentiated to a moderately differentiated squamous cell carcinoma accompanied by intense necrosis. It had also invaded the lymph nodes at the lung hilus. On the mediastinal side, tumor invasion of the LA wall was also noted (Fig. 6). The tumor was partially exposed on the visceral pleura, invading the mediastinal pleura. No evident invasion into the diaphragm was noted. Of the regional lymph nodes excised, one (#10) had a metastatic node 2 cm in size. Lung cancer in this case was rated as pT4N1M0, stage IIIB.

Discussion

Anatomically, the LA is contiguous to the lung hilus via the pulmonary vein. For this reason, a direct invasion by lung cancer originating in the lung hilus is more likely to occur in the LA than in the right atrium or both ventri-

cles. The morphological style of lung cancer's invasion of LA can be divided into two types (contiguous invasion by the primary tumor from the pulmonary vein base, and direction invasion by primary tumor or lymph node metastasis into the posterior wall of LA). Combined LA resection is considered to be more frequently indicated in the former type than in the latter.²⁾

Extended surgery to deal with LA invasion by lung cancer has a long history. In 1946, Allison³⁾ attempted lung cancer surgery by means of manipulation on great vessels within the pericardium as the first attempt of a combined LA resection. After that report, attempts of extended radical surgery involving combined LA resection in cases of lung tumor invasion of LA were published. However, most of these reports pertained to combined LA resection with the use of vascular clamp, and the outcome of these attempts was not satisfactory.⁴⁾ Among patients who received combined LA resection, some survived for long periods (though the number of such cases is not large) if complete resection of squamous cell carcinoma was possible.⁵⁾ Thus the significance of surgical treatment has been demonstrated for cases of squamous cell carcinoma where combined LA resection with clamping is possible.⁶⁾

In cases of lung cancer showing an intense invasion of the LA, however, combined LA resection by means of simple manipulation with clamping is considered inappropriate in terms of radicality of treatment and safety, and attempts of combined LA resection under CPB have recently begun to be reported.^{7,8)} Combined LA resection under CPB is advantageous because various operative techniques can be applied for resection of the LA, such as (1) resection and reconstruction of the LA wall while opening the LA under cardiac arrest, and (2) resection and suturing of the LA with the use of clamping applied to a large part of it while the heart is kept beating. However, a combined LA resection under CPB has some disadvantages, such as an increase in intraoperative blood loss under the influence of heparin and an elevation of the risk for infection resulting from temporarily compromised cellular immunity.⁹⁾ Many surgeons seem to avoid the use of CPB because of these disadvantages.

When combined LA resection with clamping is performed in cases of lung cancer invading the LA, a problem that always needs consideration is the possibility of massive bleeding resulting from dislocation of the clamp. When CPB is not used, the LA tends to be highly tense and the heart rate tends to be high, thus slightly elevating the risk of clamp dislocation. If CPB is used,

LA tension is removed by blood extraction into the bypass, and bradycardia is induced by the reduction of body temperature, probably reducing the risk of clamp dislocation. Even when dislocation of a clamp or bleeding unfortunately occurs because of injury to the LA wall during surgery, these events can be appropriately dealt with during the use of CPB.

Combined LA resection during surgical treatment of lung cancer is one of the high-risk procedures. Any error during this surgery can lead to irreversible hazards. In the present age, legal responsibility may be argued if combined LA resection is performed in a setting not prepared to apply CPB in emergency. It is therefore advisable to keep CPB ready for use when this kind of surgery is being performed.

In conclusion, this paper has presented a case of advanced lung cancer invading the LA where left pneumonectomy combined with LA resection under CPB yielded a favorable outcome. Advantages and precautions pertaining to the use of CPB during combined LA resection have been discussed.

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